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ABSTRACT

This document presents the results of a study that had as its purpose the determination of unit costs for undergraduate degree graduates by discipline at the University of Bradford in Great Britain in academic year 1981. The study is based on enrollment projections as made by present enrollment trends, and utilizes the techniques of Output Budgeting, part of what is known as Planning-Programming-Budgeting Systems (PPBS) in the U.S. Any approach to attributing costs to particular courses is unavoidably complicated. In practice, virtually every resource used by the university contributes to more than one course and nearly all costs are, in one way or another, joint costs. Academic staff teach and pursue research; technical staff service teaching and research laboratories; classrooms, laboratories and items of equipment are used by students on different courses; materials are purchased on behalf of schools of studies and it is difficult to find the course for which they are ultimately used. Nevertheless, this study tried to discover how each of these components contributes to the expense of producing each student in each discipline. Dealt with are: (1) the components of these costs per student; (2) potential academic staff costs; and (3) potential economies in teaching accommodation costs. (Author/HS)

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# POTENTIAL ECONOMIES OF SCALE AT THE UNIVERSITY OF BRADFORD

By John Dunworth and Anthony Bottomley*

## INTRODUCTION

The rate of increase of student numbers in higher education has been remarkably steady since the beginning of the century in both England and Wales and the U.S.A. with a doubling every fifteen and seventeen years respectively. However, there are now indications that the rate of increase is becoming greater. It has been calculated that in fifteen West European and North American countries, the doubling period of total student enrolments in higher education in the period immediately prior to 1966 was, with only one exception, between six and ten years.[1]

Thus there is nothing revolutionary in projections made by the United Kingdom Department of Education and Science which show the student population of British universities doubling to an estimated 394,000 in 1981.[2] Nevertheless, taxpayers may be startled by the

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[1] E.G.Edwards, "The Need for a History of Higher Education", The Changing Curriculum (London: Methuen, 1971), p.91.

[2] U.K., Department of Education and Science, Student Number in Higher Education in England and Wales, Education Planning Paper No.2, (London: H.M.S.O., 1970), Table 10, page 22.

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absolute size of the financial commitment that this expansion would involve - a rise in real expenditure in 1971/2 from £300 million (including capital and current items and student maintenance), to an estimated £573 million in 1981/2.[3] These same taxpayers may insist upon the possibility of a university education for their burgeoning families, but do they need to pay on this projected scale? Our work at Bradford seems to reveal they do not.

To get this answer we have used the techniques of Output Budgeting; part of what the Americans call Planning-Programming-Budgeting Systems (PPBS). The methodology involves attributing the total costs of university operation to the units of the various outputs produced - first degree graduates by discipline, post-graduates and research. In this paper, however, we are concerned only with first degree graduates.

Any approach to attributing costs to particular courses is unavoidably complicated and open to criticism at every stage. In practice virtually every resource used by the university contributes to more than one course and nearly all costs are, in one way or another, joint costs. Academic staff teach and pursue research; technical staff service teaching and research laboratories; classrooms, laboratories and items of equipment are used by students on different courses; materials are purchased on behalf of Schools of Studies and it is difficult to find the course for which they are ultimately used and so on.

Nevertheless we have tried to discover how each of these components contributes to the expense of producing each student in each discipline at the University of Bradford and to enumerate the potential economies which we believe are revealed.

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3. Ibid., page 33

We deal with: (1) the components of these costs per student (2) potential economies in academic staff costs and (3) potential economies in teaching accommodation costs.

## 1 COMPONENTS OF COST PER STUDENT

These components we classify as:

(i) Capital and maintenance costs

(ii) Teaching costs and

(iii) Administrative, library, student facility, general and miscellaneous costs.

Table 1 illustrates the way in which total cost per student for the various courses at Bradford is divided between the three classes of components.

Capital and maintenance costs represent an imputed rent for the use of classrooms, laboratories, libraries, offices and student facility space, such as refectories and social facilities. The rent comprises annual interest at 7 percent and amortisation payments[4] over 50 years on the insured value of buildings and non-teaching equipment, together with maintenance costs. The annual cost of each building in the University is then allocated to the different kinds of room (classrooms, laboratories, offices etc.) in proportion to the area that each type constitutes of the total usable area of the building, but with a weighting factor to allow for the greater cost of constructing laboratory space.

The annual cost of laboratories and classrooms were distributed over different undergraduates following different courses in proportion to their use by each of these students. This involved a detailed study

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[4] Interest only is charged on the land upon which the building stands as it is assumed that it will not depreciate in value.

TABLE 1: Total Cost per Student at the University of Bradford (1969 - 1970)

| Course | Capital and Maintenance Costs | | Teaching Costs | | Administrative, Library, Student Facility, General & Misc. Expendit. | | Total Cost Per Student |
|---|---|---|---|---|---|---|---|
| | £ | % of Total | £ | % of Total | £ | % of Total | £ |
| Laboratory-based Courses | | | | | | | |
| Chemical Engineering | 908 | 35 | 1089 | 43 | 560 | 22 | 2557 |
| Civil Engineering | 1030 | 41 | 956 | 38 | 523 | 21 | 2509 |
| Electrical Engineering | 1278 | 36 | 1769 | 49 | 556 | 15 | 3603 |
| Mechanical Engineering | 1768 | 44 | 1679 | 42 | 544 | 14 | 3991 |
| Applied Biology | 849 | 27 | 1639 | 53 | 622 | 20 | 3110 |
| Pharmacy | 1446 | 44 | 1329 | 40 | 519 | 16 | 3294 |
| Chemistry | 1915 | 49 | 1332 | 34 | 627 | 17 | 3874 |
| Colour Chemistry | 1888 | 48 | 1517 | 39 | 513 | 13 | 3918 |
| Materials Science | 1134 | 31 | 1874 | 51 | 672 | 18 | 3680 |
| Ophthalmic Optics | 1011 | 34 | 1484 | 49 | 504 | 17 | 2999 |
| Applied Physics | 1375 | 36 | 1635 | 46 | 672 | 18 | 3682 |
| Textile Science | 1245 | 40 | 1290 | 41 | 621 | 19 | 3156 |
| Classroom-based Courses | | | | | | | |
| Business Studies | 710 | 34 | 693 | 32 | 711 | 34 | 2114 |
| Modern Languages | 818 | 34 | 748 | 32 | 820 | 34 | 2386 |
| Social Sciences | 548 | 34 | 475 | 30 | 609 | 36 | 1632 |
| Applied Social Studies | 676 | 36 | 419 | 22 | 812 | 42 | 1907 |
| Mathematics | 907 | 39 | 744 | 33 | 656 | 28 | 2307 |
| Statistics | 563 | 31 | 613 | 35 | 599 | 34 | 1775 |

of the timetables of teaching rooms and took full account of the use of space in one School of Studies by students from other Schools.

The cost of academic staff offices was distributed in direct proportion to the relative amounts of time devoted to various activities by members of staff. The division of staff time between undergraduate teaching and other activities, such as post-graduate teaching and personal research, was based on the results of a

survey carried out in 1968 in which staff kept a diary of their activities for a term-time week.[5] The subsequent division between courses was based on a study of teaching timetables.

The cost of administrative offices and student facility space was divided equally over all students except those on "thin-sandwich" courses[6] who were weighted one half. The cost of library space was also divided equally over all students but with post-graduates weighted two.

Teaching costs comprise academic and technical staff salaries superannuation and insurance, the annual value of teaching equipment, and expenditure on materials used in teaching. The cost of academic staff was divided in the way already described. The cost of technical staff was attributed to different courses in proportion to the relative areas of teaching and research laboratories, and of their use by different courses, since it was found that their number correlated more closely with laboratory area per discipline than with numbers of academic staff.

Similar techniques were employed with respect to the cost per student of staff, stock and equipment in the university administration, library, students union and so on.[7]

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[5]The allocation of staff vacation time was based upon the relevant section of the Robbin's Report, see Committee on Higher Education, Higher Education, Appx.III (London: H.M.S.O., 1963), pp. 60-61.

[6]A "thin-sandwich" course is one with two entries of students per year, arranged so that at any one time only half the students are present in the university, the remainder receiving practical training in industry.

[7]For a detailed description of this methodology as applied to the earlier academic session of 1966-67, see: R.K.Khanna and Anthony Bottomley, "Costs and Returns on Graduates of the University of Bradford," Accounting and Business Research (No.1, Winter 1970).

The results of the foregoing calculations for the academic year 1969-70 varied widely between different courses at the University of Bradford. Laboratory-based courses in science and engineering were considerably more expensive than classroom-based courses in social sciences (see Table 1). The cost of educating an undergraduate to first degree level in science or engineering ranged from £2509 in the lowest discipline to £3991 in the highest, as against £1632 to £2386 in different social science disciplines.

Annual capital and maintenance costs varied between 27 and 49 percent of the cost of educating a student to first degree level, depending upon the course involved. Teaching costs were between 22 and 53 percent of the total, while residual and miscellaneous expenditures ranged from 13 to 22 percent of costs per student for laboratory-based courses, and 28 to 42 percent for classroom-based courses.

The comparisons between laboratory-based and classroom-based courses were even more marked when overhead administrative and other costs, which apply to all the University's students regardless of discipline, were taken out of the calculations. Then direct costs per student in classroom-based courses ranged from only £671 to £1,255 in the different social and mathematical sciences as against £1,662 to £3,187 in science and engineering.

Table 2 shows the total direct cost per student for each course, and its principal components. The percentage figures measure the proportion which each component forms of a total direct cost.

## 2 STAFF COST ECONOMIES

(a) With Increased Enrolment. It seems difficult to make economies in the foregoing cost components with present levels of student enrolment. Greater promise appears to lie in the possibility of reduced costs per student with the projected expansion in numbers over the next decade.

TABLE 2: Direct Costs per Student at the University of Bradford (1969-70)

| Course | Teaching Space (1) | | Academic Staff (2) | | Technical Staff (3) | | Secretarial Staff plus Offices (4) | | Equipment and Materials (5) | | Total Direct Costs (6) | % of Total Cost (7) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Laboratory-Based Courses | £ | % | £ | % | £ | % | £ | % | £ | % | £ | % |
| Chem.Eng. | 580 | 32 | 617 | 34 | 204 | 11 | 128 | 7 | 268 | 15 | 1797 | 70 |
| Civil Eng. | 613 | 37 | 458 | 28 | 240 | 14 | 93 | 6 | 258 | 15 | 1662 | 66 |
| Elect. Eng. | 882 | 32 | 1073 | 38 | 352 | 14 | 144 | 4 | 344 | 12 | 2795 | 77 |
| Mech. Eng. | 1388 | 44 | 981 | 31 | 452 | 14 | 120 | 3 | 240 | 8 | 3187 | 79 |
| App. Biology | 416 | 19 | 946 | 43 | 339 | 15 | 145 | 7 | 354 | 16 | 2200 | 70 |
| Pharmacy | 1026 | 42 | 549 | 22 | 474 | 19 | 114 | 5 | 306 | 12 | 2469 | 75 |
| Chemistry | 1482 | 49 | 600 | 20 | 432 | 14 | 187 | 6 | 300 | 10 | 3001 | 77 |
| Colour Chem. | 1465 | 47 | 785 | 25 | 432 | 14 | 156 | 5 | 300 | 9 | 3138 | 80 |
| Mat. Sci. | 618 | 23 | 982 | 37 | 472 | 18 | 164 | 6 | 420 | 16 | 2656 | 70 |
| Ophth. Opt. | 624 | 28 | 815 | 37 | 354 | 16 | 123 | 5 | 315 | 14 | 2231 | 74 |
| App. Physics | 859 | 32 | 743 | 28 | 472 | 18 | 164 | 6 | 420 | 16 | 2658 | 72 |
| Textile Sci. | 777 | 34 | 696 | 30 | 468 | 20 | 224 | 11 | 126 | 5 | 2291 | 73 |
| Classroom-Based Courses | | | | | | | | | | | | |
| Bus. Studies | 284 | 24 | 486 | 41 | 42 | 4 | 204 | 17 | 165 | 14 | 1181 | 56 |
| Mod. Lang. | 258 | 22 | 624 | 53 | 64 | 5 | 176 | 15 | 60 | 5 | 1182 | 50 |
| Soc. Sci. | 188 | 24 | 406 | 52 | 18 | 2 | 114 | 15 | 51 | 6 | 777 | 47 |
| App.Soc. Stud. | 116 | 17 | 327 | 49 | 24 | 4 | 136 | 20 | 68 | 10 | 671 | 35 |
| Mathematics | 339 | 27 | 652 | 52 | - | - | 172 | 14 | 92 | 7 | 1255 | 55 |
| Statistics | 126 | 14 | 544 | 62 | - | - | 144 | 16 | 69 | 8 | 883 | 50 |

We, therefore, made detailed studies of the teaching structure of nine courses. This involved analysing for each course:

(a) the annual contact hours: i.e. the number of hours teaching that a student receives each year

(b) the number of optional subjects embodied in the course, from which students may select a limited number

(c) the size of teaching groups regarded as educationally acceptable by the School of Studies

(d) the relative balance of lectures, classes, laboratory sessions and tutorials within the total contact hours.

From this data we calculated the total number of teaching meetings that must be provided at the present enrolment. We then postulated for each of nine courses successive increases in enrolment, by one student at

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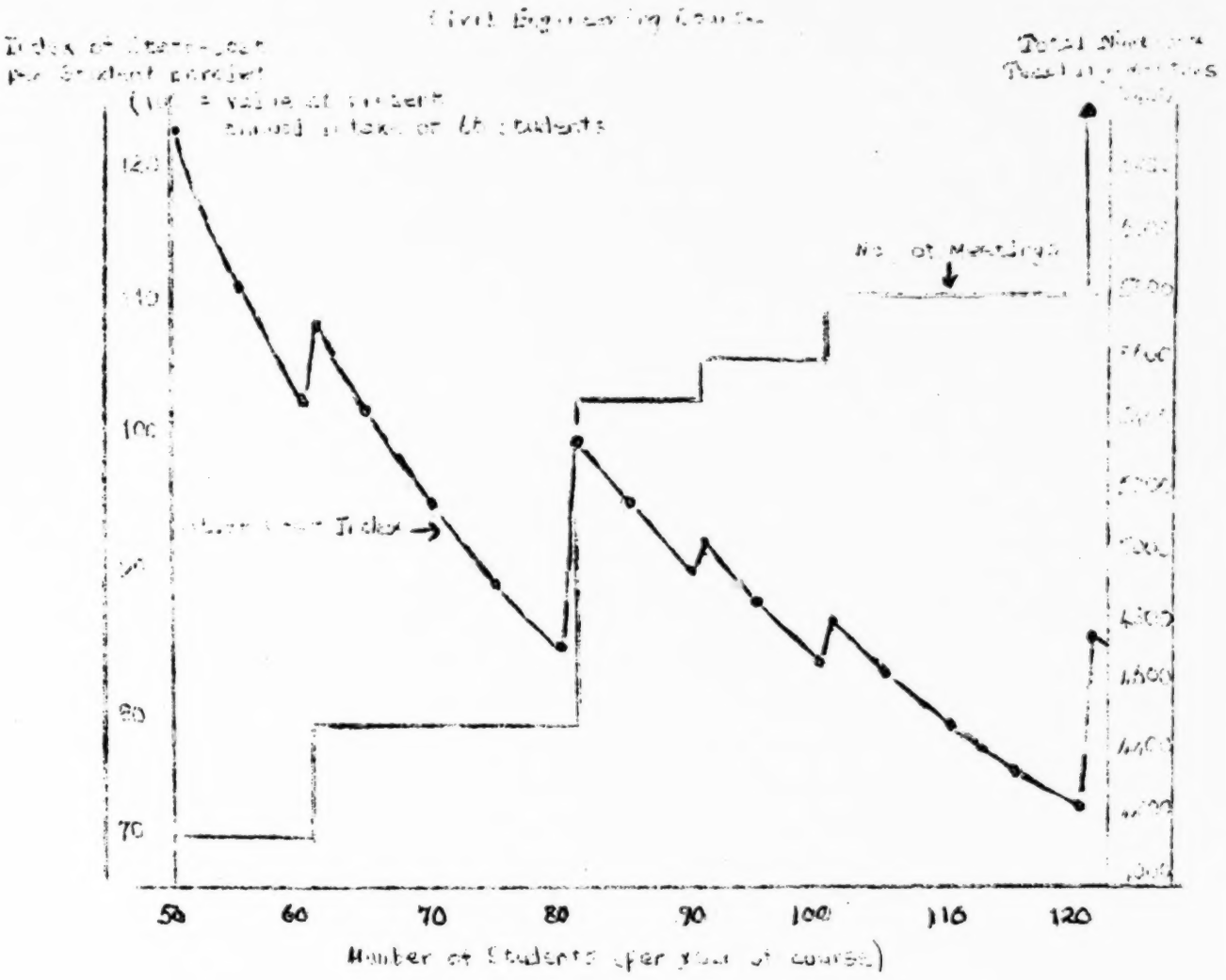
a time, up to more than twice the present number, calculating the number of teaching meetings that must be provided at each level of enrolment on each course, if the appropriate professor's maxima regarding student numbers per type of meeting were observed. Assuming a constant staff teaching load, then the number of academic staff required, and therefore the total academic staff cost of the course, is directly related to the number of meetings. We next divided the number of meetings at each level of enrolment by the number of students to obtain the number of meetings provided per student and therefore the academic staff cost per student.

Figure 1 shows the proportionate change in academic staff cost per student as enrolment increases on the Civil Engineering course from its present annual intake of sixty-six. For convenience it is expressed in index form with the value at the present enrolment equal to 100. We term this the Staff Cost Index.

For all the nine courses studied the Staff Cost Index exhibits the same form - falling as enrolment increases, but with periodic upward jumps corresponding to those levels of enrolment at which a series of teaching meetings must be duplicated because a laboratory class, seminar or tutorial reaches the maxima designated by the professors involved. The rate of fall, the points at which the jumps occur and the size of the jumps, vary from course to course, but the pattern is similar. The moral is clear - if expansion is to occur it should be to a level of enrolment corresponding to a "trough" rather than a "peak" on the Staff Cost Index.

It seems that, for nine courses examined, the per student cost of providing teaching staff falls by a minimum of 18 per cent and a maximum of 48 per cent when enrolment is increased to the "trough" nearest to twice the present number. This saving in staff cost may be achieved without increasing the number of hours per week which each staff member teaches, or reducing the number of hours of instruction

FIGURE 1: Academic Staff Cost Per Student




which each student receives. This may be done in spite of the fact that the size of seminars, tutorials and laboratory classes are held at a level which professors or their representatives think reasonable. In other words, these economies arise from expanding numbers in lectures where direct student-teacher exchanges do not normally take place. The average saving in total cost per student achieved by a carefully chosen approximate doubling of numbers, whilst maintaining

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existing course structures, is 7.7 percent through savings in staff costs alone. This implies that the overall U.K. weighted staff: student ratio could fall from its recent level of 1:11 to 1.16 without any apparent increase in teaching duties per staff member or deterioration in quality of instruction if the situation at Bradford is representative.[8]

We believe that serious study should be given to assessing the staff requirements for the proposed increase in student numbers on the basis of the number of additional teaching meetings generated, instead of by using a staff:student ratio. It would appear from our research that expansion accompanied by a constant staff:student ratio and unchanged course structures, would mean a reduction in the average weekly teaching load of staff.

(b) With existing enrolment and alternative course teaching structures. By way of comparison, we calculated the total number of teaching meetings that would have to be provided for each of the nine courses at their present enrolments as the values of the parameters listed on page 7 were varied. From the number of teaching meetings we calculated the number, and therefore the cost, of academic staff required, and the consequent effect on total cost per student.

Taking the nine courses together and using the costs outlined in the previous section as a base, the following results were obtained. A 20 percent reduction in contact hours per student caused average cost reductions per graduate of 5.1 per cent. A reduction by two in the range of optional subjects offered per degree course saved between 1 and 4.8 percent of cost per graduate. Yet increasing the

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[8] These conclusions are supported by the fact that on existing courses at the University of Bradford, teaching costs per student are inversely correlated with student numbers.

maximum size of teaching groups by 60 percent did not reduce per student costs by more than 1.7 percent on any but one of the courses examined. Similarly, replacement of small tutorials by lectures and classes produced an average saving of only 2.7 percent.

As an illustration, Table 3 presents some of the results obtained for the undergraduate course in Social Sciences.

TABLE 3: Changes in Cost per Student in Social Sciences in Relation to Changed Course Structures

| Change in Total Contact Hours | | | | | | |
|---|---|---|---|---|---|---|
| Change in Cost per Student (- = saving) | + 40% | +20% | Present Number | -20% | -40% | -60% |
| | +11.4% | + 5.7% | 0 | - 5.7% | -11.4% | -17.0% |
| Number of Optional Subjects | | | | | | |
| Change in Cost per Student (- = saving) | 2 more | 1 more | Present Number | 1 Less | 2 Less | |
| | + 3.7% | + 1.7% | 0 | - 2.0% | - 4.8% | |
| Change in Size of Teaching Group | | | | | | |
| Change in Cost per Student (- = saving) | -40% | -20% | 0 | +20% | +40% | +60% |
| | +10.5% | + 5.0% | 0 | - 3.7% | - 4.5% | - 5.7% |

It may be seen that the savings from any reasonable alteration in course structures at the present level of enrolment, are considerably less than the 7.7% saving expected from a doubling of the number of students.

## 3. ECONOMIES IN TEACHING ACCOMMODATION COSTS

Space cost economies of scale exist as a result of what appears to have been a good deal of overbuilding at the University of Bradford in recent years. This probably also applies to a greater or lesser degree to the British university system as a whole.

The current situation in the courses we examined at Bradford is that teaching is taking place in laboratories for only 41 percent of a thirty-two hour basic teaching week, and classrooms are in use for only 52 percent of the time. Furthermore, in most Schools of Studies the teaching week consists of only thirty-three weeks a year.

(a) Laboratories. The cost of laboratories forms between 11 and 35 percent of the total cost per student on science and engineering courses. Any economy of scale in this factor is likely to lead to a significant saving in total cost.

In the majority of the Schools studied, an increase in enrolment sufficient to bring laboratory use up to 80 percent of a thirty-two hour week would reduce total costs per student by between 7 and 19 percent. If this 80 percent utilisation were extended to a 60 hour week, the total cost per student could be reduced by 10 to 34 percent of the present cost. Table 4 shows the reduction in cost per student with successive increases in laboratory utilisation in each of five courses investigated.

However, there are a good many practical problems involved here in timetabling, setting up experiments and inducing academic staff to work outside the normal working week, even though the objections of the latter might be met by some supplement to salary provided out of productivity savings.

TABLE 4 Reduction in Total Cost per Student in Relation to Increased Laboratory Utilisation*

| % Laboratory Utilisation and Length of Teaching Week | Pharmacy | | Colour Chemistry | | Electrical Eng. | | Applied Biology | | Applied Physics | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total Cost per Student | % of Existing Cost | £ | % | £ | % | £ | % | £ | % |
| EXISTING | £3294 | | 3918 | | 3603 | | 3110 | | 3682 | |
| 60% @ 32 hrs. | 2957 | 90 | 2802 | 71 | 3151 | 87 | 2999 | 96 | 3275 | 89 |
| 70% @ 32 hrs. | 2777 | 84 | 2737 | 70 | 3054 | 85 | 2917 | 94 | 3215 | 87 |
| 80% @ 32 hrs. | 2671 | 81 | 2694 | 69 | 2994 | 83 | 2885 | 93 | 3131 | 85 |
| 80% @ 40 hrs. | 2593 | 79 | 2649 | 68 | 2938 | 81 | 2837 | 91 | 3083 | 84 |
| 80% @ 50 hrs. | 2536 | 77 | 2613 | 67 | 2898 | 80 | 2816 | 90 | 3039 | 82 |
| 80% @ 60 hrs. | 2497 | 76 | 2586 | 66 | 2878 | 80 | 2801 | 90 | 3023 | 82 |

* This relates to greater frequency of use only. No account is taken in these figures of the proportion of places that are unoccupied when the laboratories are in use.

Furthermore, the increases in student numbers required to achieve 80 percent or even 60 percent frequency of use are considerably in excess of anything at present envisaged for the University of Bradford, or of the likely availability of suitable students.

The University is conscious of the apparent under-utilisation of laboratories, and is at present conducting a large scale survey of laboratories in all Schools of Studies. This is attempting to measure the capacity of laboratories (the maximum number of students that could reasonably be accommodated at one time), their frequency of use, the number of students present when the laboratories are in use, and the factors inhibiting improvements in their utilisation. Preliminary results suggest that the frequency of use may be rather lower than the 41 percent quoted above and indicate occupancy factors of 60 - 70 percent when the laboratories are actually in use.

(b) Classrooms and Lecture Theatres. We went on to analyse the use of classrooms and lecture theatres in the Main Building of the

University in terms of the frequency and occupancy factors.[9] This building is the University's largest and the level of its utilization is greater than that for the University's buildings as a whole. Nevertheless, its classrooms and lecture theatres were only used on average for 55.3 percent of a 32 hour week. Even when rooms were in use, only 52.0 percent of the available seats were occupied.

It is evident that considerable economies in cost per student year could be obtained if building design and timing were to be more closely related to academic plans. For example, Figure 2 shows the discrepancy between the size of rooms required and the capacity of the rooms available in the Main Building. Of a total of 619 meetings scheduled each week during the academic year 1971-72, 423 (69 percent) were held in rooms within a greater size range than was actually required. More detailed analysis showed that 334 meetings (54 percent) were held in rooms of more than twice the required size, include 142 (23 percent) where the rooms were at least four-times too big.

Table 5 shows the number of rooms of each size which are actually required, assuming the 66.7 percent frequency factor regarded as normal by the U.K. University Grants Committee (UGC) within our thirty-two hour week. A comparison of the last two columns shows the differences between the rooms actually available in the Main Building and those which were really required during the academic year 1971-72. As a result of this study, some of these surplus classrooms are being altered during the present vacation. Two of the 31-50 seat rooms and four of the 13-30 seat rooms are being converted into a total of seven 12-seat classrooms, five 7-seat tutorial rooms and seven staff offices. By re-scheduling the small meetings in the new small rooms it is hoped to release a further three classrooms in the 13-50 seat ranges during the 1972-3 session for non-teaching uses.

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[9] The frequency factor is the number of hours a room is used expressed as a proportion of the total hours available in the normal teaching week. The occupancy factor is the proportion of seats in a room that are occupied when the room is in use. For the University as a whole the frequency factor is 32.0% and the occupancy 46.6%, meaning that on average seats are occupied for only 7¾ hours of a 32-hour teaching week.

FIGURE 2: Room-hours Available and Meeting-hours Occurring per Week, Analysed by Size of Room/Meeting. 1971-72

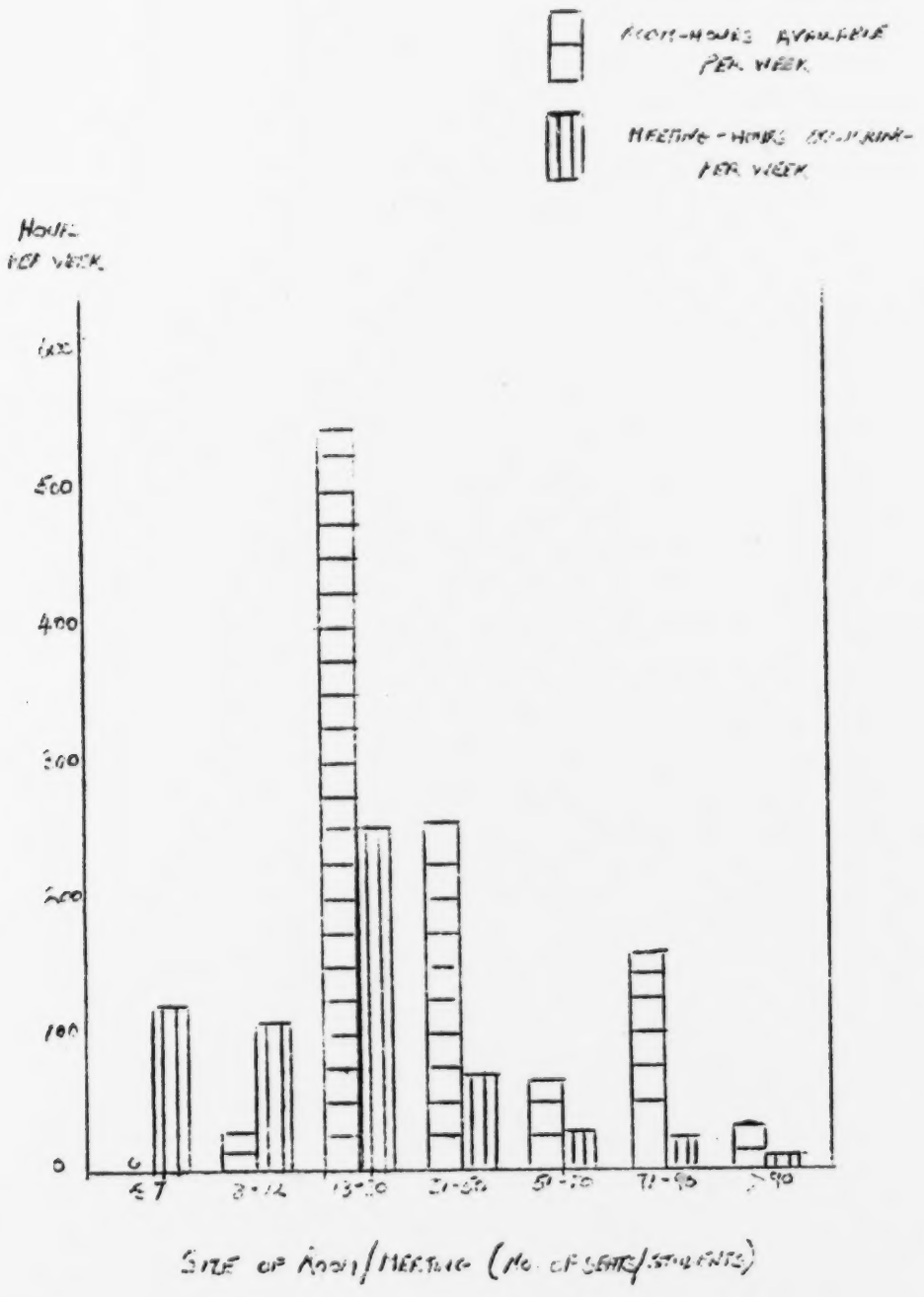


TABLE 5: Room Requirements in the Main Building.

| Range of Meeting Size (No. of Students) | No. of Meetings of this Size Scheduled per Week | No. of Rooms Required (with 66.7% frequency of use) | No. of Rooms Available |
|---|---|---|---|
| ≤ 7 | 125 | 6 | - |
| 8-12 | 110 | 6 | 1 |
| 13-30 | 252 | 12 | 17 |
| 31-35 | 71 | 4 | 8 |
| 51-70 | 28 | 2 | 2 |
| 71-90 | 24 | 2 | 5 |
| > 90 | 9 | 1 | 1 |
| TOTAL | 619 | 33* | 34 |

* The total of 33 rooms required is an overestimate, as it is obtained after all the elements of the total have been rounded up to the nearest integer. If the elements are added to two decimal places, and the total rounded up, a figure of 29 is obtained. (Applying the 66.7 percent directly to the 619 meetings also gives 29 rooms).

Figure 3 further demonstrates how the aggrevating factor of low seat-occupancy compounds the overall underutilization arising from the low frequency of classroom usage. The situation varies widely at different hours of the day. Considerable potential economies of scale would therefore exist with increases in enrolment which used classrooms and seats in accordance with the varying percentages of capacity detailed in Table 6, which follows the pattern for potential laboratory use outlined in Table 4.

It is again clear from Table 6 that costs per student year at Bradford could be substantially reduced given the various postulated room x seat occupancy factors. This might be achieved either by expanding enrolment on existing courses, or by transferring the surplus teaching accommodation to other uses or to new courses. It might, however, be difficult to get the precise required increment in student numbers in this respect or to time-table in accordance with the exigencies of an 80 percent utilization factor. In any event, the reader may choose whatever percentage of capacity he thinks reasonable when identifying potential economies per student year from Table 6.

FIGURE 3: Room and Seat Utilisation in the Main Building by Hour of Day - 1971-72.

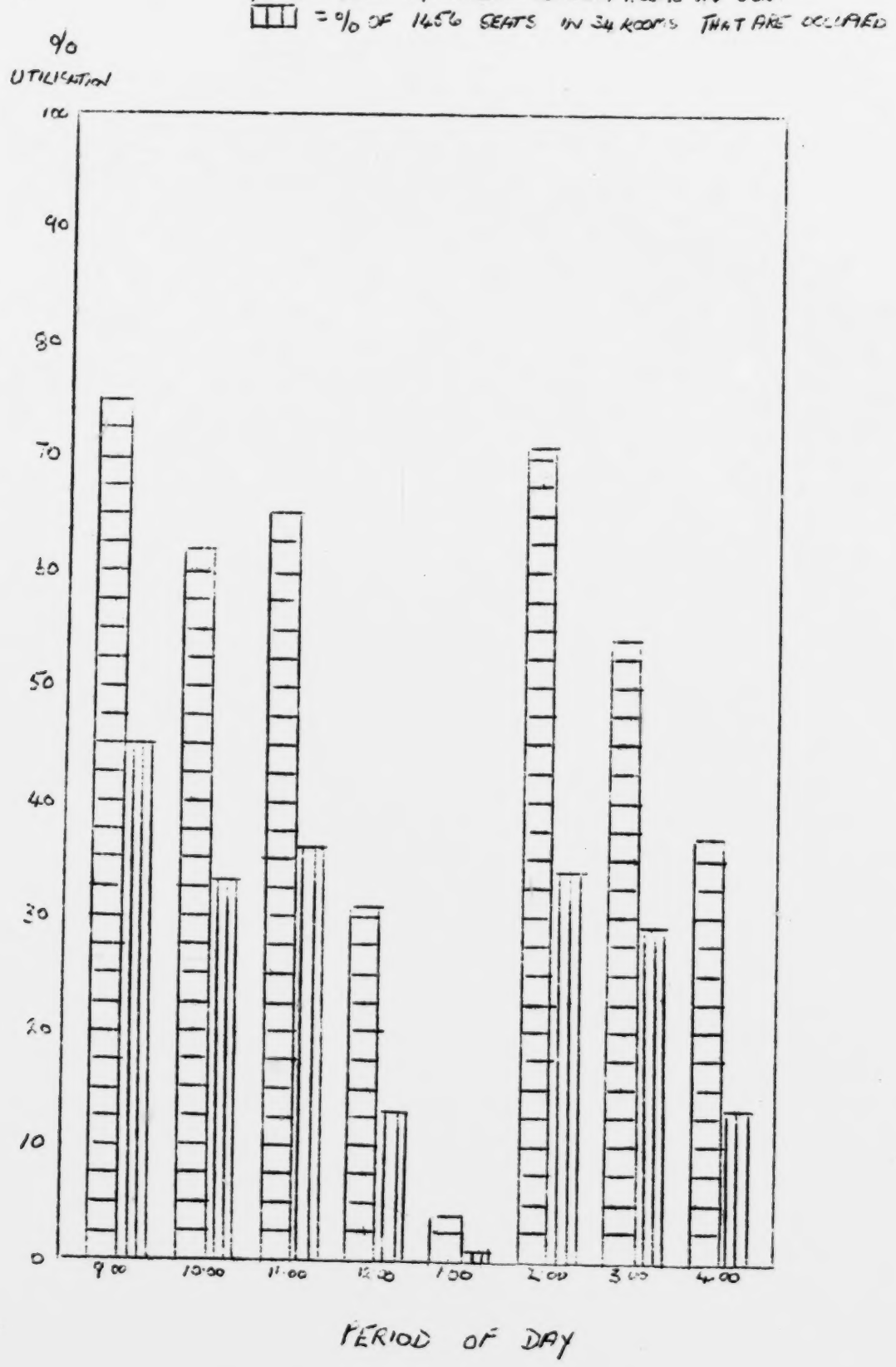


TABLE 6: Percentage Saving in Total Cost per Student in Relation to Improved Utilisation of Classrooms.

| Course | Percentage Saving in Total Cost | | | | | |
|---|---|---|---|---|---|---|
| | 32 hour week | | | 40 hour week | 50 hour week | 60 hour week |
| | 60% Freq. | 70% Freq. | 80% Freq. | | | |
| Chem.Eng. | 1.9 | 2.3 | 2.6 | 3.4 | 3.7 | 3.9 |
| Civil Eng. | 3.8 | 4.1 | 4.4 | 5.0 | 5.2 | 5.3 |
| Elec. Eng. | 1.7 | 2.0 | 2.2 | 2.7 | 2.9 | 3.0 |
| Mech. Eng. | 1.3 | 1.6 | 1.9 | 2.8 | 3.0 | 3.2 |
| Biology | 0.9 | 1.2 | 1.3 | 1.8 | 1.9 | 2.0 |
| Pharmacy | 0.7 | 0.9 | 1.1 | 1.7 | 1.8 | 1.9 |
| Chemistry | 0.9 | 1.3 | 1.6 | 2.5 | 2.7 | 2.9 |
| Colour Chem. | 1.8 | 2.1 | 2.2 | 2.6 | 2.7 | 2.8 |
| Materials Sci. | 3.2 | 3.4 | 3.5 | 3.9 | 4.0 | 4.1 |
| Oph.Optics | 0.5 | 0.9 | 1.1 | 1.8 | 2.0 | 2.2 |
| App. Physics | 3.2 | 3.8 | 4.2 | 5.3 | 5.6 | 5.8 |
| Mod.Langs. | 2.2 | 2.8 | 3.3 | 4.6 | 4.9 | 5.2 |
| Social Sci. | 4.0 | 4.6 | 5.0 | 6.1 | 6.5 | 6.7 |
| App. Soc. Stu. | 2.3 | 2.8 | 3.2 | 4.4 | 4.7 | 4.9 |
| Maths. | 2.6 | 3.7 | 4.6 | 7.1 | 7.8 | 8.3 |
| Statistics | 1.7 | 2.5 | 3.0 | 4.7 | 5.2 | 5.5 |

Notes: An occupancy factor of 75% (i.e. the U.G.C. norm) is assumed in all cases.
Frequency Factor (Freq.) is assumed to be 80% for the 40, 50 and 60 hour weeks.

It might again be argued that the thirty-three week working year is not sacrosanct, and it is clear that further economy would lie in using the buildings for forty-eight, rather than a thirty-three, weeks per year. This could permit an intake of two groups of students per year. This is already done on several of the "thin-sandwich" courses at the University of Bradford, and doubling the throughput of students per year goes a long way towards cutting the cost of each one.

We calculated the savings per student year in this respect with a conversion of what are now thirty-three week courses to two intakes over a forty-eight week year. The possible cost reductions range from 4 to 12 percent with the pessimistic assumption that all costs other than for accommodation increase pro rata with the increase in student numbers.

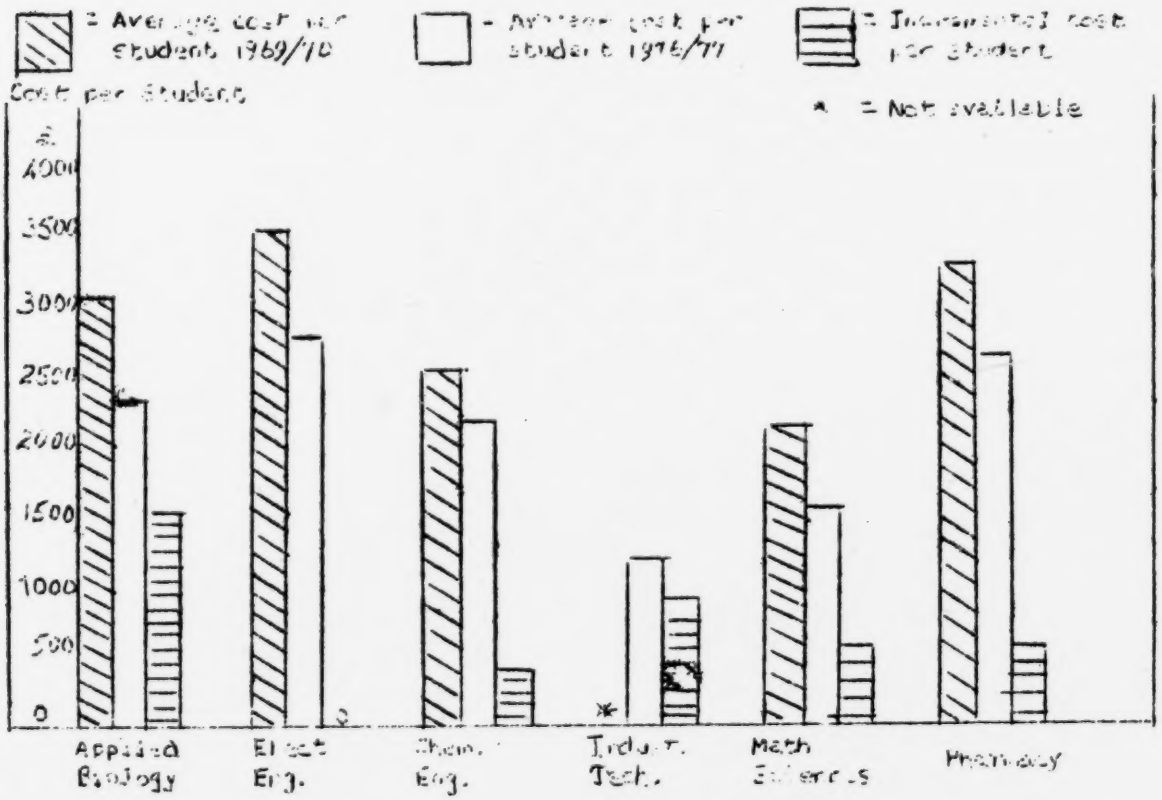
The greatest savings are, of course, in the laboratory-based courses. If, on the other hand, we optimistically assume that there will be no increase in library expenditures and student facility space and only a 50 percent increase in technical staff expenditure, equipment and material costs, costs per student fall by between 18 and 24 percent for laboratory-based and 15 and 19 percent for classroom-based courses.

The savings from greater utilisation of buildings, either more intensively, or for more hours per week or more weeks per year, are thus substantial. On the other hand, our investigations showed that any "reasonable" reductions in building standards and costs could not be expected to yield more than a small fraction of these sorts of savings. A 10 percent reduction in the capital cost of buildings and non-teaching equipment, for instance, would result in reductions in total cost per student of only 1.7 percent to 3.1 percent.

## 4. QUINQUENNIAL EXPANSION PLANS

Current expansion plans within the University confirm our view that considerable economies of scale exist. This was seen to be so when we costed the expansion plans for six existing courses during the 1972-77 quinquennium. These costings were based on estimates of staff and other resource requirements made by professors or their representatives, and were in no way influenced by any of the potential economies identified by the research reported on above. It was calculated that, taken together, professors' proposals for a 66 percent increase in student numbers on the six courses, could be met with an increase in total costs of only 14 percent. The cost of each additional student (the Incremental Cost) would be only 22 percent of the present average cost, with the result that the average cost per student on these courses would fall by 31 percent over the quinquennium. Figure 4 shows for each of the six proposals, the cost per student in 1969-70, and after expansion in 1976-77; and the incremental cost for each of the additional students. It is assumed that surplus accommodation is brought into use during the existing teaching hours and years, and that course structures remain the same.

FIGURE 4: Average and Incremental Costs of Six Expansion Proposals for the Quinquennium 1972-3 to 1976-7.




## 5. CONCLUSIONS

It seems that considerable potential economies of scale exist in higher education if the University of Bradford is in any way representative. If enrolment is doubled or thereabouts with present accommodation surpluses and course structures, then average costs per student may fall by between 11 and 38 percent, depending upon the course involved and the assumptions made. Further substantial cost reductions would arise with a course structure which handled two intakes a year.

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It is evident that building plans have been sanctioned in a manner which fits university requirements more like a sack than a glove. Architects and academic planners should now be joined in providing tailor-made building programmes over time. Unfortunately, the universities themselves cannot be relied upon to do this. They have no incentive to economise on space-use where buildings are construed as free goods and no interest or amortization charges need be carried by the individual institution.

We became increasingly aware during our research of such absence of built-in incentives to use resources efficiently. It was most obvious in the case of buildings, but it was also the case in respect of current items of expenditure. Under the present system of British university financing and planning, universities know in advance, subject to certain specific exceptions, their income for a five-year period and the approximate number and type of students they will enrol. Thus cost per student over the quinquennium has been determined before the students enter. Once the quinquennium has begun there are few real ways to effect economies since revenue, and therefore expenditure, have already been determined. Nor is there any incentive for universities to cut costs per graduate. The critical time to achieve economies is therefore before quinquennial recurrent grants are fixed, and the power to do this lies with the University Grants Committee and the Department of Education and Science, not with the individual universities. Thereafter, universities would need to react to such economies by implementing them as painlessly as possible.

Finally, we would emphasise that the nation would be getting the worst of both worlds if it reduced the projected rates of expansion mentioned at the outset, while roughly maintaining the present grant per student year. Fortunately, there are signs that this will not happen and the considerable economies of scale which we have here identified may, perforce, become of interest throughout the British university system.